NASA TECHNICAL MEMORANDUM

NASA TM X-53667
October 23, 1967

NASA TM X-53667

SIMULATION TEST REPORT FOR THE S-IVB ORBITAL WORKSHOP CREW QUARTERS FLOOR AND WALL GRIDS

By Manufacturing Research and Technology Division
Manufacturing Engineering Laboratory

NASA

George C. Marshall Space Flight Center, Huntsville, Alabama

TECHNICAL MEMORANDUM X-53667

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By

Manufacturing Research and Technology Division

George C. Marshall Space Flight Center
Huntsville, Alabama

ABSTRACT

This report presents the simulation techniques and hardware used to evaluate two S-IVB orbital workshop crew quarters floor grids. The first tests were conducted on an 0.08-m (3-in.) grid with 0.15-m (6-in.) triangles removed from the floor pattern at 0.66-m (26-in.) intervals to facilitate translation by an astronaut or test subject. The second study was conducted on a grid with continuous pattern of 0.15-m (6-in.) triangular openings. The tests were conducted in the zero-g engineering mock-up of the Manufacturing Engineering Laboratory.

ACKNOWLEDGMENT

This document was prepared from a publication entitled "Evaluation of Orbital Workshop Floor and Wall Grid Design" (SE-16-67), by R. H. Caneer, Space Experiment Group, Hayes International Corporation, to fulfill the requirements of a Technical Directive issued by the Manufacturing Research Technology Division, Manufacturing Engineering Laboratory, George C. Marshall Space Flight Center, Huntsville, Alabama.

Additional recognition is due J. G. Tisdale of the RCA Service Company for compilation of the information contained herein.

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MANUFACTURING ENGINEERING LABORATORY
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SUMMARY

An evaluation of two S-IVB orbital workshop crew quarters floor and wall grids (Fig. 1) was conducted in the zero-g engineering mock-up of the Manufacturing Engineering Laboratory. A Preliminary Design Review (PDR) indicated that a modification in the grid would be required, providing handholds to facilitate crew translation during the installation and operation of equipment in the crew quarters.

INTRODUCTION

Following the second burn of the S-IVB Stage, the astronauts will convert the spent stage into crew quarters. The transition will be conducted in a zero-g environment, requiring a source of mobility and stabilization during the installation of equipment. To fulfill this requirement, a PDR recommended that the 0.08-m (3-in.) floor and wall grid be modified to provide handholds or that a larger grid be designed.

The task of evaluating the grids was submitted to MSFC's Manufacturing Engineering Laboratory where tests were conducted in the zero-g engineering mock-up.

SIMULATION HARDWARE

The test hardware used to evaluate the 0.08-m (3-in.) grid consisted of two grid sections, 0.91 m × 2.67 m (3 ft × 8 ft 9 in.), joined by mechanical fasteners. These grid sections were removed from the S-IVB Orbital Workshop Mock-up in Building 4755 for use in this evaluation. The sections were milled

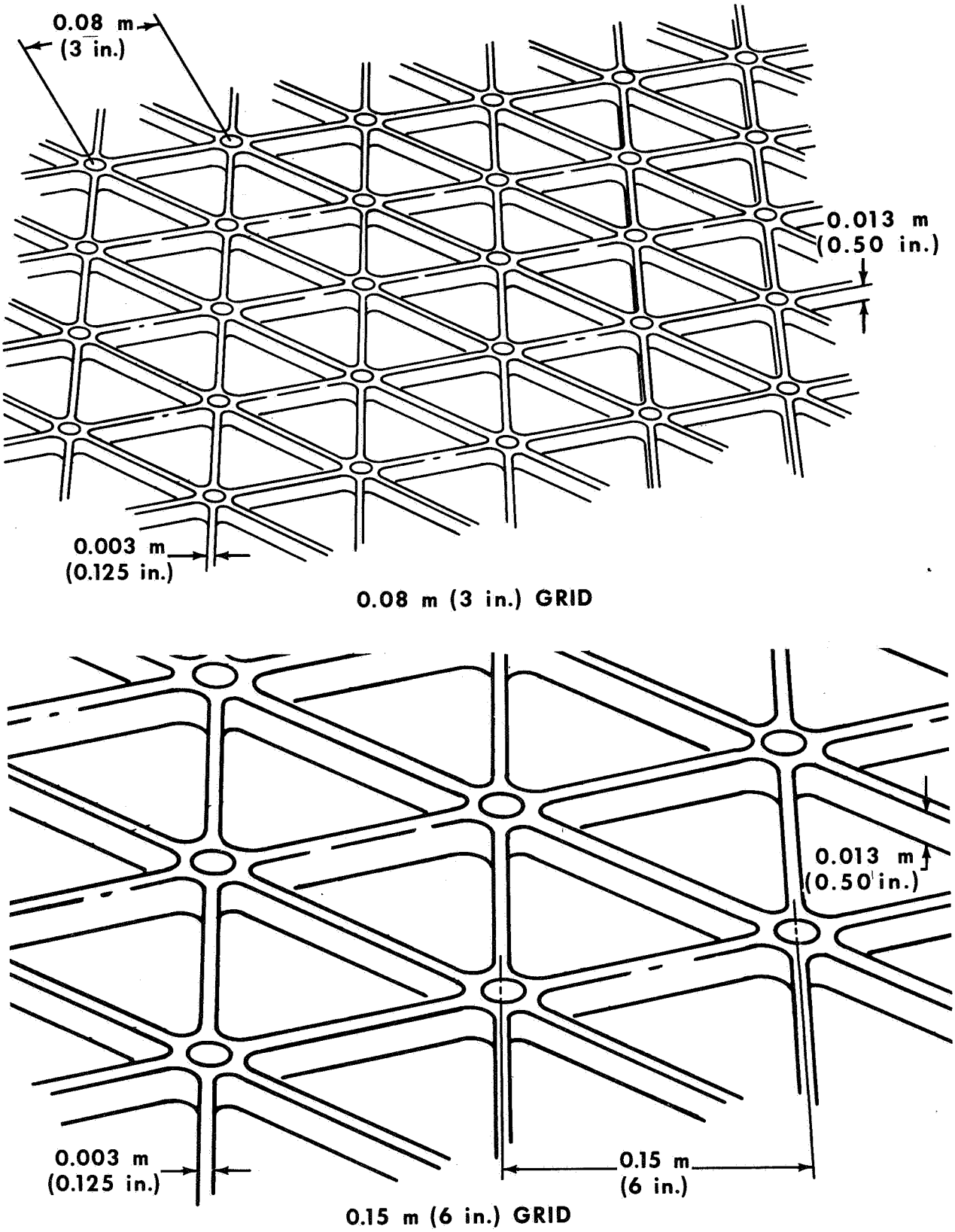

FIGURE 1. S-IVB ORBITAL WORKSHOP CREW QUARTERS
FLOOR AND WALL GRIDS

from 0.013-m (0.5-in.) aluminum alloy. The 0.15-m (6-in.) handholds were spaced 0.66 m (26 in.) apart, in rows 0.57 m (22.5 in.) apart. A removable handhold was placed at one end of the 3.05-m (10-ft) axis. The two sections of grid were joined to make a test area of 1.83 m × 2.67 m (6 ft × 8 ft 9 in.). The grid was then placed on six 0.31-m (12-in.) tubular supports and placed on the bottom of the zero-g engineering mock-up (Fig. 2).

The second grid design was a continuous pattern of thin-section bars that form the sides of 0.15-m (6-in.) triangular openings. A grid section, 1.83 m x 3.05 m (6 ft x 10 ft), mounted on three longitudinal beams, was placed on 0.31-m (12-in.) tubular supports and set on the floor of the zero-g engineering mock-up. A removable handhold device was inserted at one end of the 10-ft axis.

SIMULATION PERSONNEL

Principal participants in this test were a test subject, an assistant diver, two safety divers, a photographer, and a test engineer. The test subject, an engineer, was trained in the use of a pressure suit. He was briefed on the task before each dive and debriefed after the dive. The Mark IV Goodrich suit was used in the test.

The two safety divers, who used SCUBA gear, were certified safety divers familiar with safety procedures of the facility. An assistant diver, who also used SCUBA gear, was assigned to the test subject to make alterations on the test hardware and to provide additional on-the-spot engineering changes requested by the test subject or test engineer. These divers were briefed on the task prior to each dive and debriefed following each dive. The test engineer directed the test procedure and conducted briefing and debriefing of personnel.

SIMULATION TECHNIQUES

Although three test subjects were used to obtain data for the evaluation, only one test subject was functioning during any given time. The test subjects translated across the grid in SCUBA gear and then in the Mark IV pressure suits with thermal gloves, as shown in Figure 3. Tasks "A" and "B" consisted of translating the perimeter of the grid using only handholds. In Task "C" the test

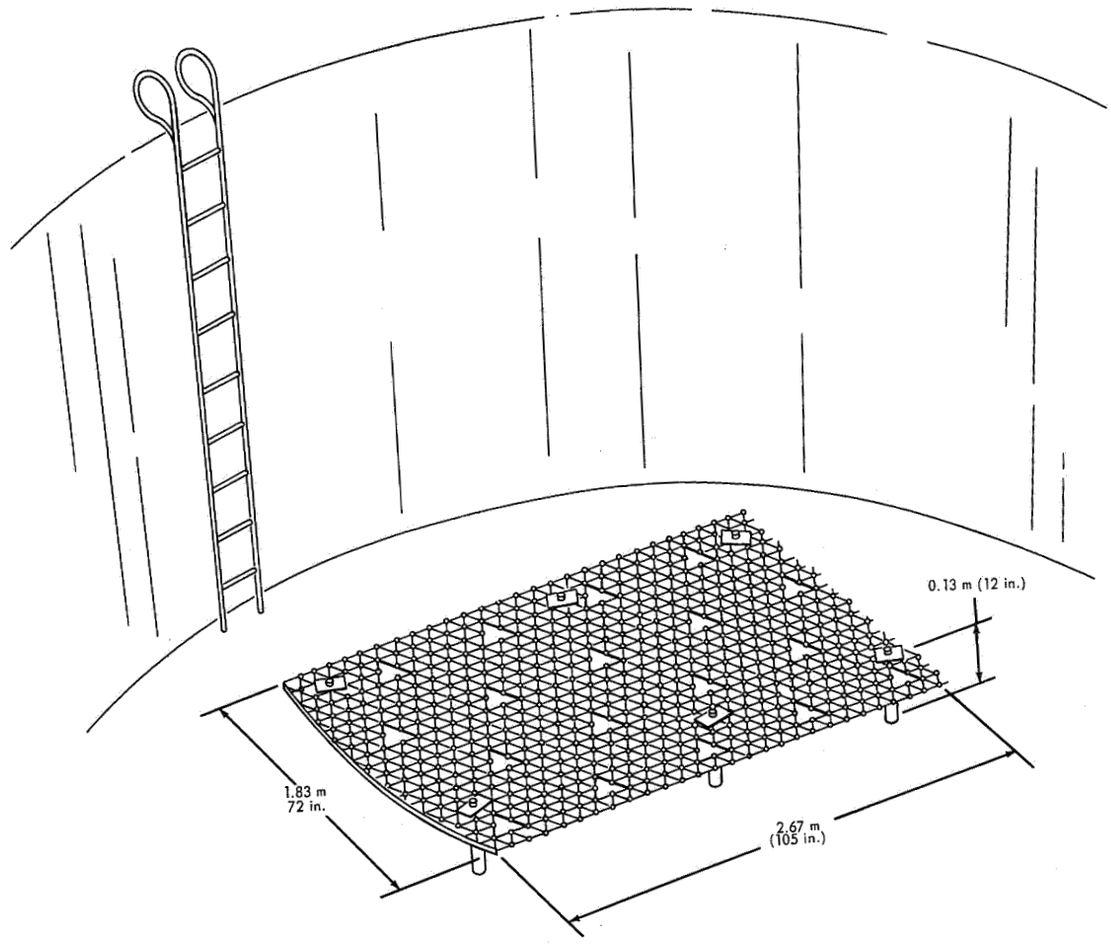

FIGURE 2. THE 0.08-m (3-in.) GRID IN THE ZERO-G ENGINEERING MOCK-UP

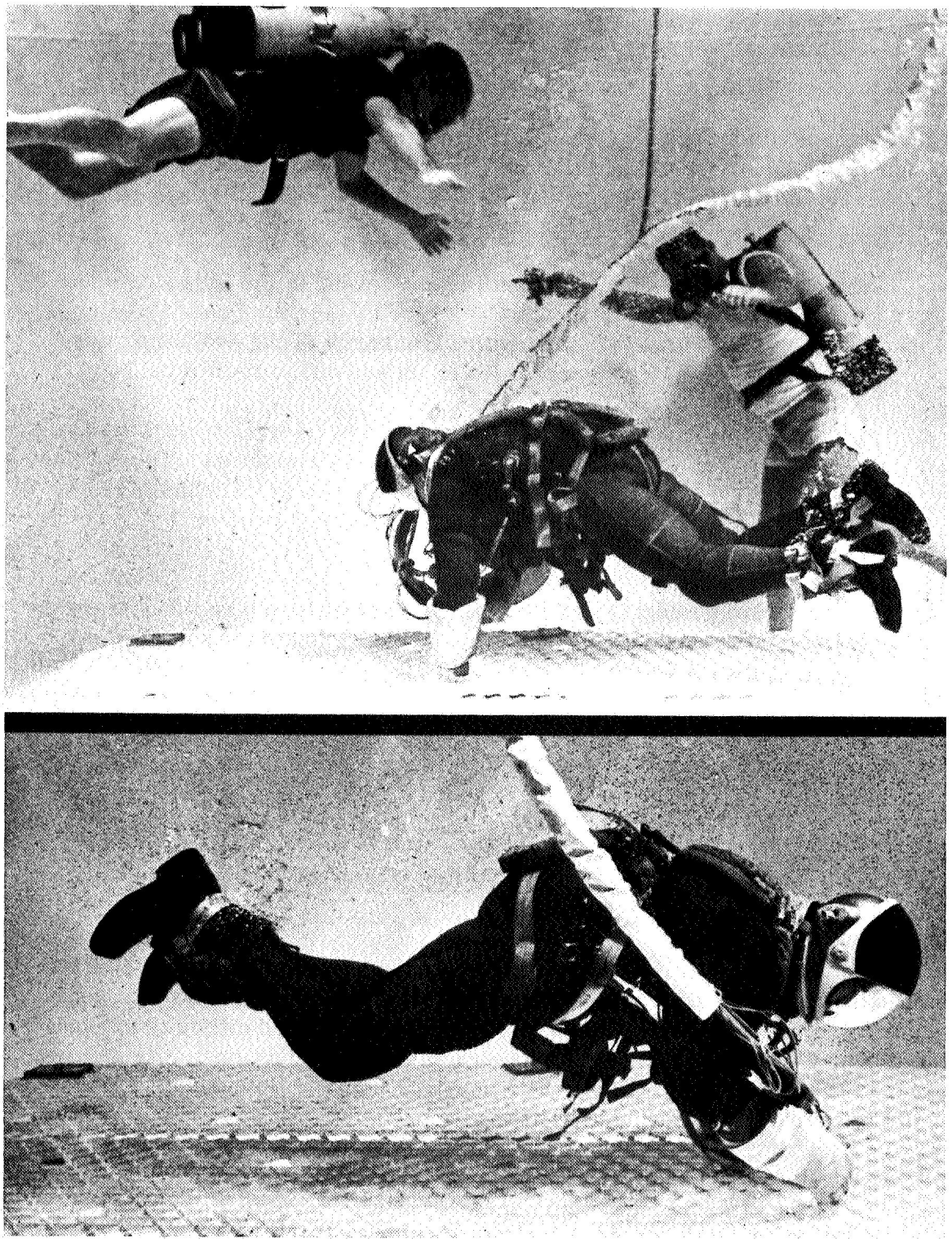

FIGURE 3. TEST SUBJECT TRANSLATION ACROSS GRID
(Top Photo Shows Safety Divers With Test Subject)

subject translated the long axis of the grid and removed and replaced the quick-disconnect type handhold while stabilizing himself with footholds. After completing the established test procedure, each test subject was permitted to experiment at will with the grid.

Data obtained from the evaluation were recorded in the following manner:

1. Audio Tape - The entire transcript of the evaluation was recorded on an audio tape recorder.

2. Video Tape - Three closed circuit television cameras monitored the entire evaluation. The optimum coverage of the three was switched to the master monitor and recorded on a video tape recorder.

3. Photography - Color motion pictures and black-and-white stills were made during the evaluation.

4. Medical - Strip charts provided information on respiration and heart functions of the test subject.

Data sheets of the translation study are presented in the appendixes.

CONCLUSIONS AND RECOMMENDATIONS

The 0.08-m (3-in.) triangular grid openings were determined to be too small for fingerholds; however, the interval spacing of the 0.15-m (6-in.) handholds seemed to be optimum. Each test subject encountered difficulty gripping the 0.15-m (6-in.) handholds with the thermal gloves. Additional difficulty was reported during attempts to insert the army-type boots while evaluating the feasibility of using the handholds as footholds. The pattern can easily be varied, since the handholds can be made in any desired location by cutting three webs from the constant triangular metal pattern.

The test subjects agreed that the 0.15-m (6-in.) triangular grid is much more satisfactory for translation than the 0.08-m (3-in.) triangular grid. They encountered no difficulty in locating the handhold cutouts; however, in a minimum lighting situation it would be advantageous to "highlight" the handholds with darker tones (Fig. 4).

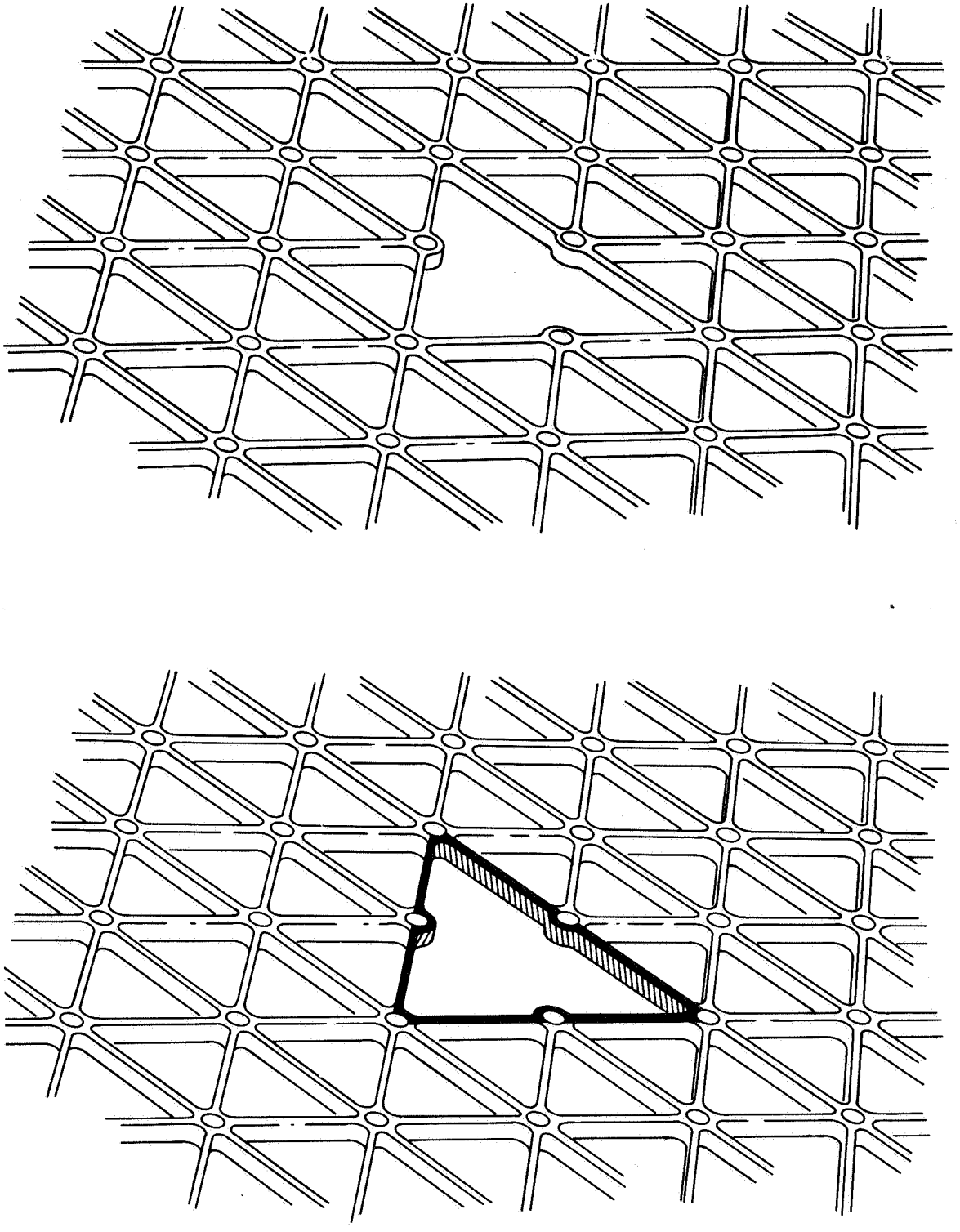

FIGURE 4. COMPARISON OF GRIDS
WITH AND WITHOUT HANDHOLDS HIGHLIGHTED

An evaluation of the numerical test data provides no correlation between the time required to perform each task and the relative difficulty in performing a similar task, probably because the test subjects could not translate at a constant effort on all trials and tasks.

APPENDIX A

TEST DATA FROM 0.08-METER (3-INCH) GRID

TEST SUBJECT: J. L. Stevenson DATE: 28 Aug 67

TEST SUBJECT DRESS: SCUBA

DATA TAKEN BY: R. Shafer

TASK PERFORMED:

Task A: Translate Perimeter of Grid Using Hands Only - Moving Clockwise.

Task B: Translate Perimeter of Grid Using Hands Only - Moving Counterclockwise.

Task C: Translate Up Center of Grid Using Hands and Feet, Remove and Replace Handhold.

TRIAL NO.	TIME (Seconds)			REMARKS
	TASK A	TASK B	TASK C	
1	13	11	17	
2	11	10	20	
3	8	10	29	
4	10	11	15	
5	9	14	21	
6	12	12	15	
7	10	11	19	
8	11	12	20	
9	11	12	16	
10	14	15	19	
11	12	14	17	
12	13	13	21	

REMARKS: Wide variation in Task C times due to nonpositive engagement when replacing handhold.

TEST SUBJECT: W. G. Hunter DATE: 28 Aug 67

TEST SUBJECT DRESS: SCUBA

DATA TAKEN BY: R. Shafer

TASK PERFORMED:

Task A: Translate Perimeter of Grid Using Hands Only - Moving Clockwise.

Task B: Translate Perimeter of Grid Using Hands Only - Moving Counter-clockwise.

Task C: Translate Up Center of Grid Using Hands and Feet, Remove and Replace Handhold.

TRIAL NO.	TIME (Seconds)			REMARKS
	TASK A	TASK B	TASK C	
1	14	11	30	
2	11	10	25	
3	9	8	23	
4	9	9	30	
5	9	10	26	
6	9	9	28	
7	10	9	21	
8	9	10	21	
9	10	11	22	
10	10	11	24	
11	9	10	19	
12	10	10	19	

REMARKS: Wide variation in Task C times due to nonpositive engagement when replacing handhold.

TEST SUBJECT: C. W. Williams DATE: 5 Sept 67

TEST SUBJECT DRESS: SCUBA

DATA TAKEN BY: R. Hal Caneer

TASK PERFORMED:

Task A: Translate Perimeter of Grid Using Hands Only - Moving Clockwise.

Task B: Translate Perimeter of Grid Using Hands Only - Moving Counter-clockwise.

Task C: Translate Up Center of Grid Using Hands and Feet, Remove and Replace Handhold.

TRIAL NO.	TIME (Seconds)			REMARKS
	TASK A	TASK B	TASK C	
1	13	12	15	
2	15	13	14	
3	13	11	16	
4	13	12	13	
5	12	12	13	
6	13	13	13	
7	14	12	14	
8	13	15	16	
9	14	12	14	
10	13	13	18	
11	13	13	13	
12	13	12	14	

TEST SUBJECT: W. G. Hunter DATE: 6 Sept 67

TEST SUBJECT DRESS: Pressure Suit - Goodrich at 3.5 psi reported

DATA TAKEN BY: R. Hal Caneer

TASK PERFORMED:

Task A: Translate Perimeter of Grid Using Hands Only - Moving Clockwise.

Task B: Translate Perimeter of Grid Using Hands Only - Moving Counter-clockwise.

Task C: Translate Up Center of Grid Using Hands and Feet, Remove and Replace Handhold.

TRIAL NO.	TIME (Seconds)			REMARKS
	TASK A	TASK B	TASK C	
1	31*	32*	106	Task C Translation Time
2	53	57	39	28
3	65	54	43	31
4	62	65	39	27
5	63	54	28	18
6	54	54	46	27**
7	53	55	35	24
8	54	54	38	28
9	53	51	32	22
10	60	55	51	37
11	50	50	56	28**
12	45	51	47	20**

REMARKS: * Cut corners a little short. Test subject had trouble using footholds

** Had to plug in handhold twice

TEST SUBJECT: C. W. Williams DATE: 7 Sept 67

TEST SUBJECT DRESS: Pressure Suit - Goodrich at 3.5 psi reported

DATA TAKEN BY: R. Hal Caneer

TASK PERFORMED:

Task A: Translate Perimeter of Grid Using Hands Only - Moving Clockwise.

Task B: Translate Perimeter of Grid Using Hands Only - Moving Counter-clockwise.

Task C: Translate Up Center of Grid Using Hands and Feet, Remove and Replace Handhold.

TRIAL NO.	TIME (Seconds)			REMARKS
	TASK A	TASK B	TASK C	
1	39	42		
2	36	36		Translation time for Task
3	40	43		C not required per
4	42	36		Richard Heckman
5	37	35		9-6-7
6	34	35		
7	31	33		
8	37	30		
9	32	34		
10	34	39		
11	31	33		
12	41	37		

REMARKS: Used 6" handholds only, very successfully.

TEST SUBJECT: J. L. Stevenson DATE: 8 Sept 67

TEST SUBJECT DRESS: Pressure Suit - Goodrich at 3.5 psi reported

DATA TAKEN BY: R. Hal Caneer

TASK PERFORMED:

Task A: Translate Perimeter of Grid Using Hands Only - Moving Clockwise.

Task B: Translate Perimeter of Grid Using Hands Only - Moving Counter-clockwise.

Task C: Translate Up Center of Grid Using Hands and Feet, Remove and Replace Handhold.

TRIAL NO.	TIME (Seconds)			REMARKS
	TASK A	TASK B	TASK C	
1	54	50		
2	36	113		
3	45	42		
4	31	40		
5	41			*
6				
7				
8				
9				
10				
11				
12				

REMARKS: * Test aborted due to lost glove. It is necessary to depressurize suit to replace glove. Glove fingers too short.

TEST SUBJECT: J. L. Stevenson DATE: 22 Sept 67

TEST SUBJECT DRESS: Pressure Suit - Goodrich

DATA TAKEN BY: R. Hal Caneer

TASK PERFORMED:

Task A: Translate Perimeter of Grid Using Hands Only - Moving Clockwise.

Task B: Translate Perimeter of Grid Using Hands Only - Moving Counter-clockwise.

Task C: Translate Up Center of Grid Using Hands and Feet, Remove and Replace Handhold.

TRIAL NO.	TIME (Seconds)			REMARKS
	TASK A	TASK B	TASK C	
1	41	28	Not	
2	29	28	Required	
3	28	27	Per	
4	23	25	R. Heckman	
5	25	27	9-22-67	
6	30*	23		*Gloves began
7	32	33		to slip down at
8	32	31		this time.
9	**			
10				
11				
12				

REMARKS: Test initiated to complete aborted run of 9-1-7, the data from which was submitted September 8, 1967.

** Test aborted due to complete test subject exhaustion

TEST SUBJECT: C. W. Williams DATE: 22 Sept 67

TEST SUBJECT DRESS: Pressure Suit - Goodrich

DATA TAKEN BY: R. Shafer

TASK PERFORMED:

Task A: Translate Perimeter of Grid Using Hands Only - Moving Clockwise.

Task B: Translate Perimeter of Grid Using Hands Only - Moving Counter-clockwise.

Task C: Translate Up Center of Grid Using Hands and Feet, Remove and Replace Handhold.

TRIAL NO.	TIME (Seconds)			REMARKS
	TASK A	TASK B	TASK C	
1	28	29	Not	
2	27	32	Required	
3	25	27	Per	
4	28	28	R. Heckman	
5	27	22	9-22-67	
6	26	23		
7	24	24		
8	27	27		
9	25	25		
10	25	24		
11	23	23		
12	24	25		

REMARKS: Suit size incorrect for subject, somewhat uncomfortable. No side play of hand when tightly gripping transverse grid member.

APPENDIX B
TEST DATA FROM 0.15-METER (6-INCH) GRID

TEST SUBJECT: J. L. Stevenson DATE: 22 Sept 67

TEST SUBJECT DRESS: Pressure Suit - Goodrich .

DATA TAKEN BY: R. Hal Caneer

TASK PERFORMED:

Task A: Translate Perimeter of Grid Using Hands Only - Moving Clockwise.

Task B: Translate Perimeter of Grid Using Hands Only - Moving Counter-clockwise.

Task C: Translate Up Center of Grid Using Hands and Feet, Removed Replace Handhold.

TRIAL NO.	TIME (Seconds)			REMARKS
	TASK A	TASK B	TASK C	
1	31	26	Not	
2	23	25	Required	
3	25	22	Per	
4	22	23	R. Heckman	
5	26	23	9-22-67	
6	24	23		
7	28	25		
8	24	24		
9	20	22		
10	24	20		
11	24	20		
12	22	19		

REMARKS: Subject had a natural tendency to use first two fingers of each hand to grip and translate.

TEST SUBJECT: J. L. Stephenson DATE: 26 Sept 67

TEST SUBJECT DRESS: SCUBA

DATA TAKEN BY: R. Shafer

TASK PERFORMED:

Task A: Translate Perimeter of Grid Using Hands Only - Moving Clockwise.

Task B: Translate Perimeter of Grid Using Hands Only - Moving Counter-clockwise.

Task C: Translate Up Center of Grid Using Hands and Feet, Remove and Replace Handhold.

TRIAL NO.	TIME (Seconds)			REMARKS
	TASK A	TASK B	TASK C	
1	34	32	13	
2	33	36	14	
3	38	37	14	
4	38	35	14	
5	37	34	13	
6	37	36	14	
7	28	24	14	
8	26	25	13	
9	25	24	14	
10	19	23	12	
11	23	24	13	
12	23	22	13	

REMARKS: Great difference in times as opposed to 3" triangle grid times apparently due to subject's unnecessarily slow and deliberate pace.

TEST SUBJECT: C. W. Williams DATE: 26 Sept 67

TEST SUBJECT DRESS: SCUBA

DATA TAKEN BY: R. Shafer

TASK PERFORMED:

Task A: Translate Perimeter of Grid Using Hands Only - Moving Clockwise.

Task B: Translate Perimeter of Grid Using Hands Only - Moving Counter-clockwise.

Task C: Translate Up Center of Grid Using Hands and Feet, Remove and Replace Handhold.

TRIAL NO.	TIME (Seconds)			REMARKS
	TASK A	TASK B	TASK C	
1	23	19	12	
2	24	20	13	
3	23	22	11	
4	23	20	12	
5	23	19	12	
6	21	19	11	
7	22	22	13	
8	21	23	12	
9	22	23	12	
10	22	22	12	
11	21	23	11	
12	21	22	14	

REMARKS: Subject had difficulty obtaining footholds because of beam under grid obstructing grid openings. Also, subject's shoes too large to easily enter openings.

APPROVAL

NASA TM X-53667

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Manufacturing Research and Technology Division

The information in this report has been reviewed for security classification. Review of any information concerning Department of Defense or Atomic Energy Commission programs has been made by the MSFC Security Classification Officer. This report, in its entirety, has been determined to be unclassified.

This document has also been reviewed and approved for technical accuracy.

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